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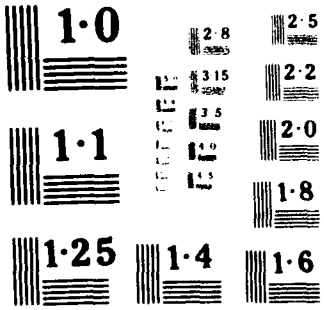
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Effect of Sealants of the Sound Absorption
Coefficients of Acoustical
Friable Insulating Materials

by

James L. Wayman and Mary K. Lory

October 1984

Technical Report for Period
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Acoustical friable insulating materials (AFIM), which often in the past contained asbestos, have been used for sound control since the mid 1930's. Because of their widespread use and the ease of fiber dissemination friable asbestos materials are considered to be the major source of asbestos fiber contamination in the indoor environment. Encapsulation of asbestos materials with a commercial sealant product is one of several methods used to control potential asbestos exposure in rooms. A sealant product that preserves most of the acoustical properties of the material is preferred

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AFIM sample materials were treated with 6 types of sealants and the effects on normally incident absorption coefficients from 100 to 2500 Hz were measured using a fixed, dual-microphone technique. "Penetrating" type sealants were found to have a less detrimental effect on sound absorption than those of a "bridging" type.

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Since the 1930s friable spray-applied asbestos insulation has been used in the construction industry - primarily for fireproofing and sound control. The term "friable" describes a material which is porous and easily crumbled in the hand readily releasing its fibers. Acoustical friable insulation material (AFIM) which contains asbestos is still found on ceilings and walls in many public buildings (including schools). Recognition of health hazards related to asbestos exposure has prompted federal agencies to enact regulations concerning exposure levels.

AFIM has excellent sound absorption properties because of its porosity. Attempts to treat AFIM to reduce asbestos fiber release, unfortunately, may also reduce this porosity, which could result in disruption of speech communication or increased risk of hearing loss from higher noise levels and, in some cases, violation of noise exposure regulations.

Encapsulation, an economical means to abate potential asbestos exposure, involves the spray application of a sealant which coats the fiber matrix of the AFIM substrate, restricting the release of fibers. In an EPA study conducted by Batelle Columbus Laboratories (Mirick, W. et al., 1981), encapsulants were investigated and separated into two categories: those that penetrate AFIM, coating individual fibers - but still leaving air spaces, and those that bridge the surface pores of the material with a continuous membrance. Penetrating sealants exhibited penetration from 1/2 to 1-1/4 inch into the AFIM, were low in percent solids by weight, and had low viscosities. Bridging sealants showed minimal penetration, were above 35 percent solids by weight, and had high viscosities - greater than 1,000 centipoises. Whether there would be a measurable acoustic difference between the two categories of sealants on AFIM had not yet been demonstrated. The purpose

of this research was to determine which of the two types of encapsulants, penetrating or bridging, when applied to AFIM permitted more sound absorption.

METHOD

An evaluation was conducted to determine the acoustic characteristics of the AFIM before and after encapsulation. As was done in the Batelle study, a non-asbestos AFIM was used as a test substrate for comparison of encapsulants. An impedance tube procedure was used to measure sound absorption of small specimens. The recently developed tube method using two stationary microphones mounted on the tube wall at known distances from the specimen was the method of choice. This "two-microphone random-excitation" method has been described by Seybert and Ross (1977) as a more accurate and efficient procedure than the standard Standing Wave Ratio method (ASTM C384-58, 1972) for determination of acoustic properties for frequencies below 2500 Hz.

<u>Test Substrate</u>: AFIM, provided by a product manufacturer, consisted of a 1-3/8 inch hollow cellulose fiber matrix which had been uniformly spray-applied to 1/2 inch thick styrofoam sheets.

<u>Specimen Preparation</u>: Six sealants were spray-painted over the AFIM samples in accordance with the technical specifications of the U.S. Navy (Lory and Coin, 1981). Encapsulants were allowed to cure five days before testing. Encapsulants represented the range of generic products used for encapsulation of AFIM. The physical and chemical properties of the products tested are shown in Table 1. Because of possible surface irregularities, three specimens were prepared for each of the six encapsulants and for the untreated (control) AFIM. Specimens were 4-1/2 inches square, so that they would overlap the

Table 1. Description of Encapsulants

Encapsulant Code Number	Generic Description	Solid Content By Weight (%)	Viscosity (cps)	Classification
1	Acrylic vinyl acetate copolymer	10	5	Penetrating
2	Acrylic	21	8	Penetrating
3	Vinyl acrylic copolymer emulsion	46	6,000	Bridging
4	Acrylic	59	2,250	Bridging
5	Polyvinyl acetate copolymer	51	2,500	Bridging
6	Elastomeric copolymer (butyl rubber)	68	52,000	Bridging

outside diameter of the measuring tube. During testing, uniform pressure was applied to the specimens, but the back of the specimen directly over the tube's opening was left unobstructed.

<u>Instrumentation</u>: Figure 1 is a diagram showing the measuring arrangement for the instrumentation used. The acoustic source was provided by the analog-to-digital converter. The high frequency portion of the input signal was attenuated by a low-pass filter. The digital filter automatically filtered the signal, limiting the bandwidth to the frequency range 0-3200 Hz. A MacIntosh 30-watt amplifier was used to amplify the signal and activate a 3-inch diameter Delco speaker mounted on one end of the measuring tube. The tube was a 3-inch inner diameter PVC pipe. It was 12 inches long with a 1/4-inch rubber cushion on the open end to provide a seal between the tube and the test specimen.

Two AKG C451-EB microphones with 3/4-inch diameters were used. The microphones were modified with custom machined heads which contained ports only on their tips. The microphones were flush mounted on the tube walls with their centers spaced 1-3/4 inches apart. The microphone signals were conditioned by an AKG dual channel preamplifier and digitized by the analog-to-digital converter. The signal analyzer measured the auto- and cross-spectral densities of the two microphone signals. These data were stored in the minicomputer memory of the controller for processing. Results were provided in graphic form by the plotter.

<u>Measures</u>: Band-limited white noise provided the acoustic signal which produced a randomly fluctuating sound field in the measuring tube. The total time record of the data was made up of 30 separate [illegible] signals which were averaged to provide a spectral estimate. By this "ensemble averaging", the random error of the spectrum was reduced

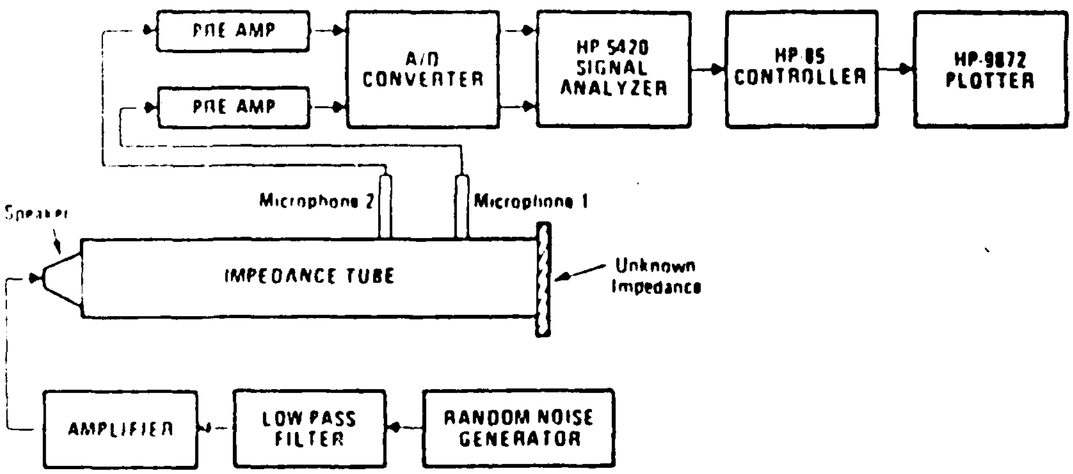

Figure 1. Experimental Set-up Simplified Block Diagram

to an acceptable level. The acoustic properties of the specimens were evaluated for 256 narrow frequency bands of 12.5 Hz which were evenly spaced across the spectrum from 0-3200 Hz. Points representing the center frequency of every third band were printed on graphs, and the interval between each point was 37.5 Hz.

For each specimen a time record of data was collected from which the following measurements were calculated: 1) the resistive and 2) the reactive parts of the specific impedance ratios, 3) the reflection coefficient, and 4) the phase angle between the incident and reflected sound waves. From the raw data, graphs were plotted that showed the averaged data from the three individual specimens tested for each encapsulant and the untreated control. All data points below 100 Hz and above 2500 Hz were disregarded because of questionable validity of the measurements and reliability of the instruments for those frequencies.

RESULTS

Figures 2 and 3 show the reflection coefficient results. More sound reflection occurred for encapsulated specimens than was demonstrated by controls. As expected, reflection coefficients for treated specimens were greatest above 1000 Hz. Sealing an acoustical product decreases surface porosity, thus restricting airflow through the material. Absorption for high frequencies is determined primarily by the amount of surface openings (Sabine and Moulder, 1979).

The highest reflection coefficients in the speech frequency range (500-2500 Hz) for the controls was near .1 at 500 Hz and at 2500 Hz. Control coefficients were near zero between 1000 and 2000 Hz. AFIM specimens coated with encapsulants 1, 2, and 3 revealed coefficients that differed from controls by less than .02 throughout the speech

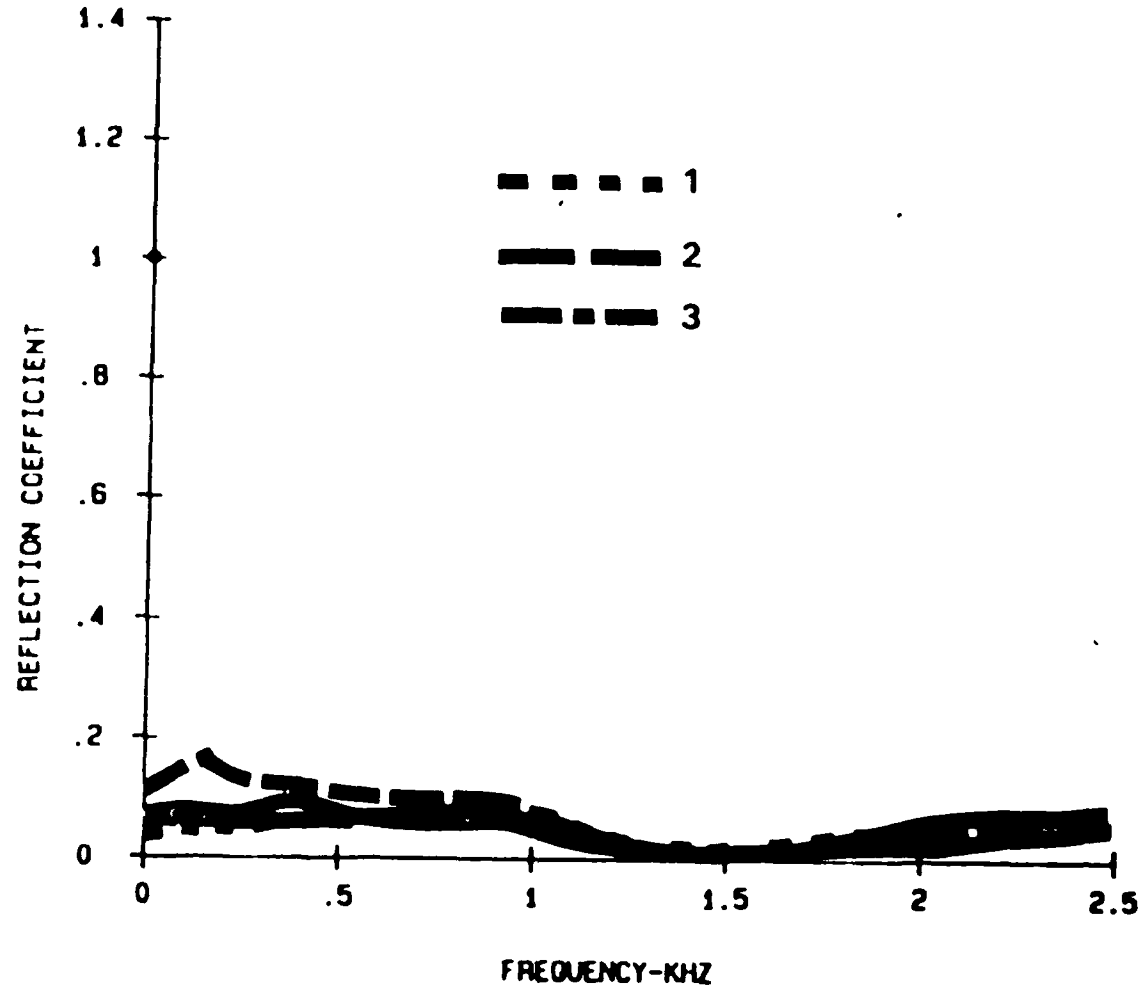

Figure 2. Reflection Coefficient Results of Encapsulants 1, 2, 3 and Control

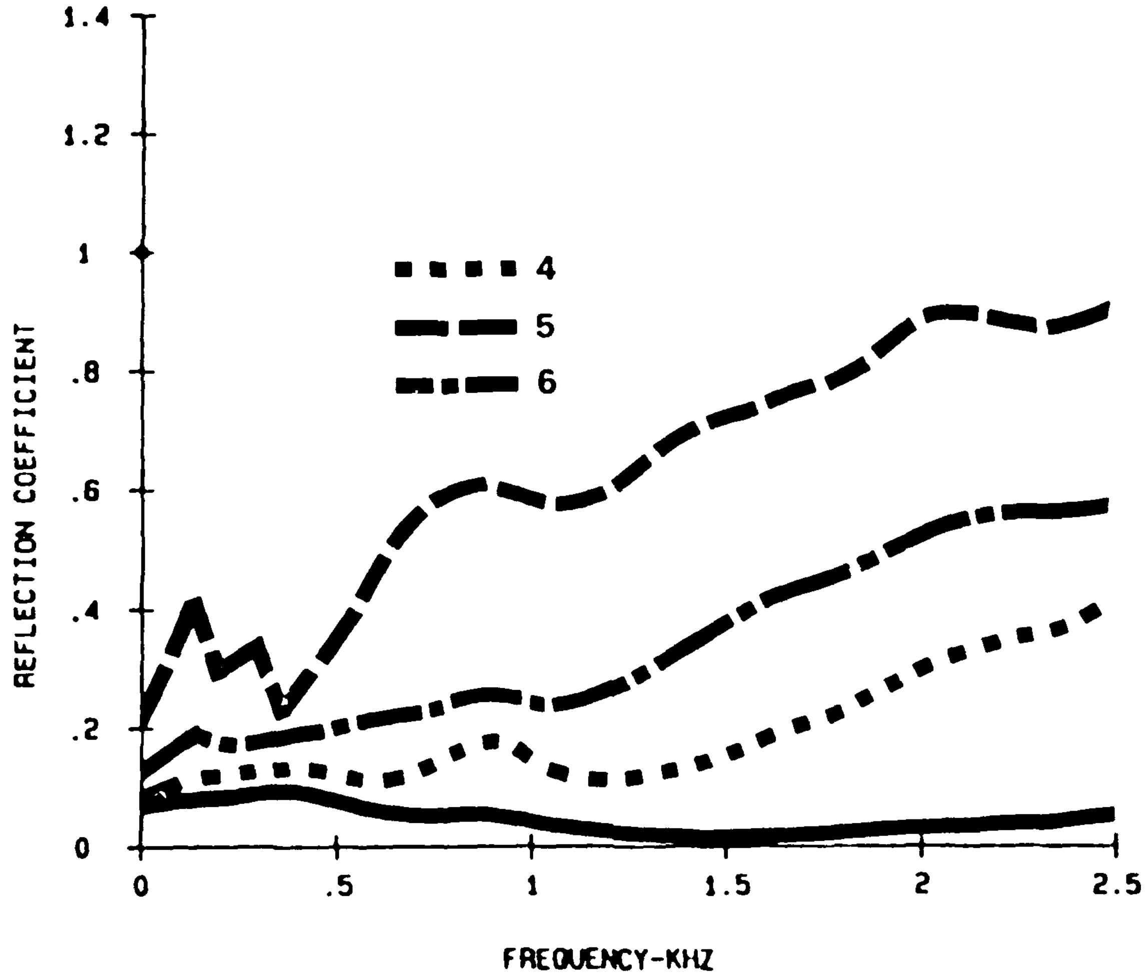

Figure 3. Reflection Coefficient Results of Encapsulants 4, 5, 6 and Control

frequency range. A considerable increase in sound reflection was revealed for bridging encapsulants 4, 5, and 6.

When reflection coefficients are raised for acoustical materials in a room, the reverberation times for given frequencies usually become greater. In a room 32 x 27 x 12 feet high, reverberation times greater than .75 second would adversely affect speech intelligibility for normal hearing persons (Knudsen and Harris, 1950). For the hearing impaired, reverberation times should be near .5 second (John, 1960).

A reduction in sound absorption would also increase background noise levels, producing an undesirable effect on speech communication. The direct acoustic signal of interest must be at least 12 dB above the ambient noise level to ensure adequate speech communication (Newby, 1972). A better signal-to-noise ratio is required for hearing impaired persons (Ross, 1978). Increasing reflection coefficients for AFIM by more than .15 or .2 may not allow the material to meet recommendations for adequate sound control.

The normal incidence coefficients here serve to assess the relative effects of various sealants on one type of AFIM. The instrumentation permitted a partial analysis of the audible frequency range. Future research may lead to development of an apparatus with which to explore higher frequencies and would permit a comprehensive evaluation of acoustical characteristics which could have an adverse effect on the hearing mechanism as well as on speech communication.

CONCLUSION

These findings provide a preliminary guide to the selection of sealants for AFIM on the basis of their acoustical effects. Considerable cost may be saved by choosing a sealant that meets the requirements of asbestos hazard prevention while at the same time preserves

the necessary acoustic properties of the AFIM. Penetrating sealants were shown to produce less sound reflection than bridging products on AFIM specimens. The selection of a penetrating sealant would be the preferred choice wherever acoustical considerations are important.

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